United States Patent [19]

Michaud et al.

[11] **4,352,656**

[45] **Oct. 5, 1982**

[54] **GAS APPLIANCE CONTROL DEVICE**

[75] Inventors: **Roger P. Michaud**, Lewiston, Me.; **Douglas B. Campbell, deceased**, late of Gilford, N.H., by Diane Campbell, administratrix

[73] Assignee: **American Stabilis, Inc.**, Lewiston, Me.

[21] Appl. No.: **77,628**

[22] Filed: **Sep. 21, 1979**

[51] **Int. Cl.**[3] **F23H 5/00**; F23N 5/00; F23Q 9/08

[52] **U.S. Cl.** **431/72**; 431/74; 431/46

[58] **Field of Search** 431/72, 73, 74, 78, 431/79, 80, 24, 25, 26, 46, 67, 71, 70

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,223,138	12/1965	Brown	158/28
3,582,249	6/1971	Hodgson	431/70
3,895,241	7/1975	Cooper	307/311
4,025,283	5/1977	Ray	431/45
4,082,493	4/1978	Dahlgren	431/25
4,137,428	1/1979	Federico et al.	179/1 SW

Primary Examiner—Samuel Scott

Assistant Examiner—Wesley S. Ratliff, Jr.

Attorney, Agent, or Firm—Finnegan, Henderson, Farabow, Garrett & Dunner

[57] **ABSTRACT**

An electrical control circuit is disclosed for controlling the operation of a pilotless gas system including an igniter and a gas supply valve, wherein the gas supply valve is initially opened a predetermined time after the igniter is activated, and the igniter is subsequently deactivated a predetermined time after the gas supply valve is opened. Specifically, a control first signal is produced to activate the appliance, which control first signal is delivered to a first logic circuit for activating the igniter, and to a first delay circuit which produces a second signal delayed from the first signal by a first predetermined time period. The second signal is delivered to a gas supply valve control circuit to open the supply valve, whereupon a detector produces a third signal in response to opening of the valve. A second delay circuit produces a fourth signal delayed from the third signal by a second predetermined time period, the fourth signal being applied to the first logic circuit for deactivating the igniter a predetermined time period after the opening of the gas supply valve.

8 Claims, 2 Drawing Figures

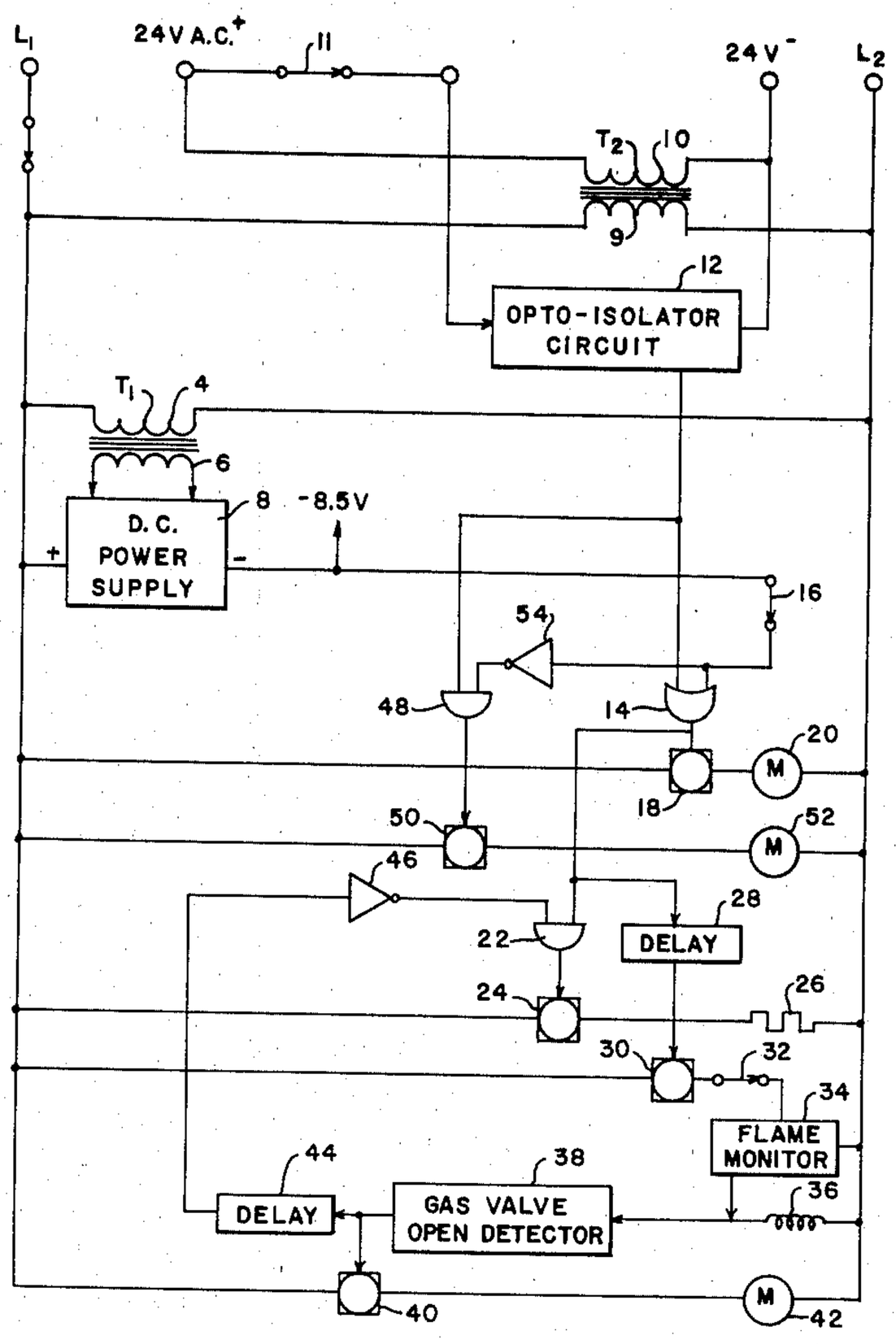


FIG. 1

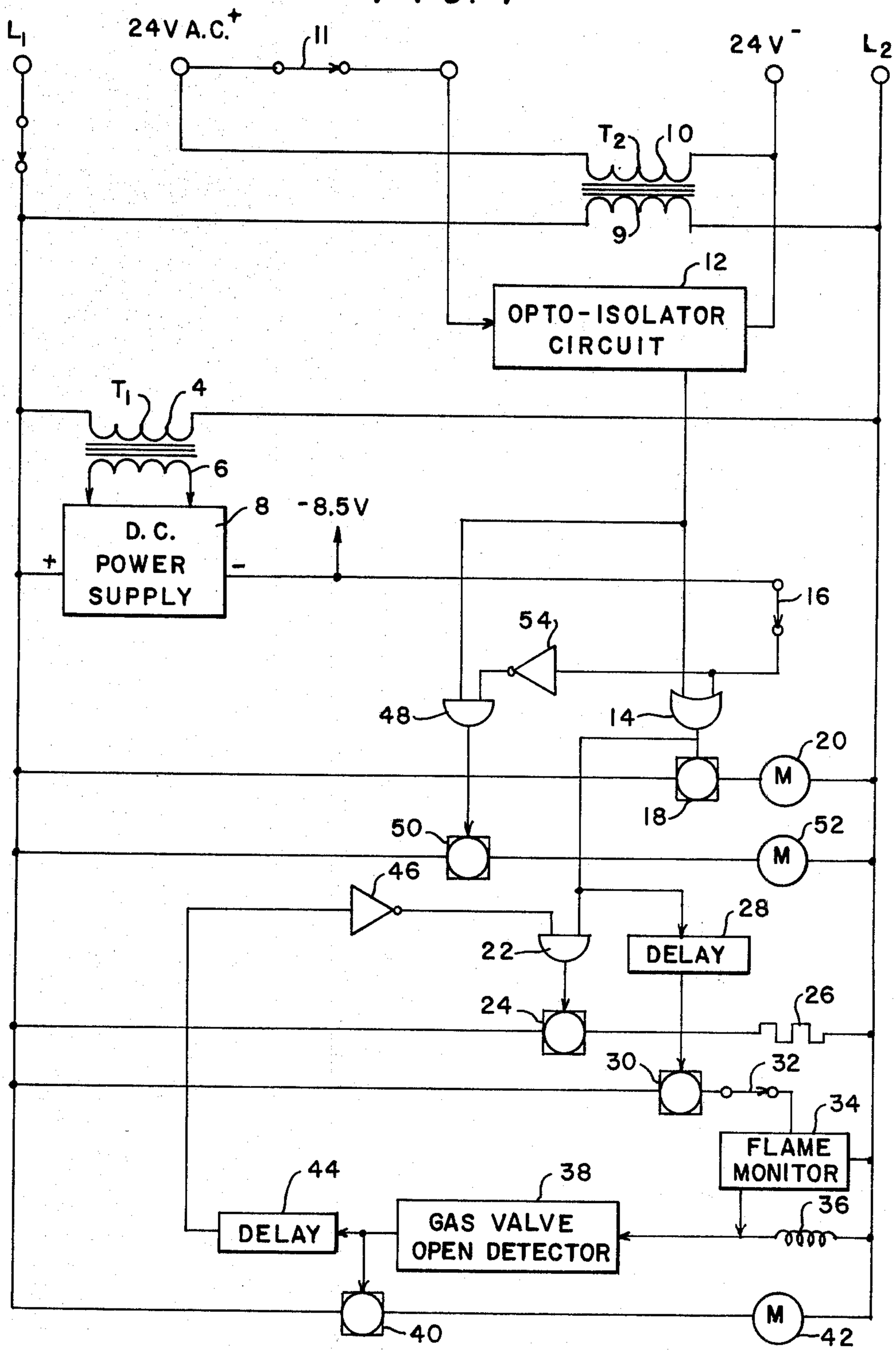
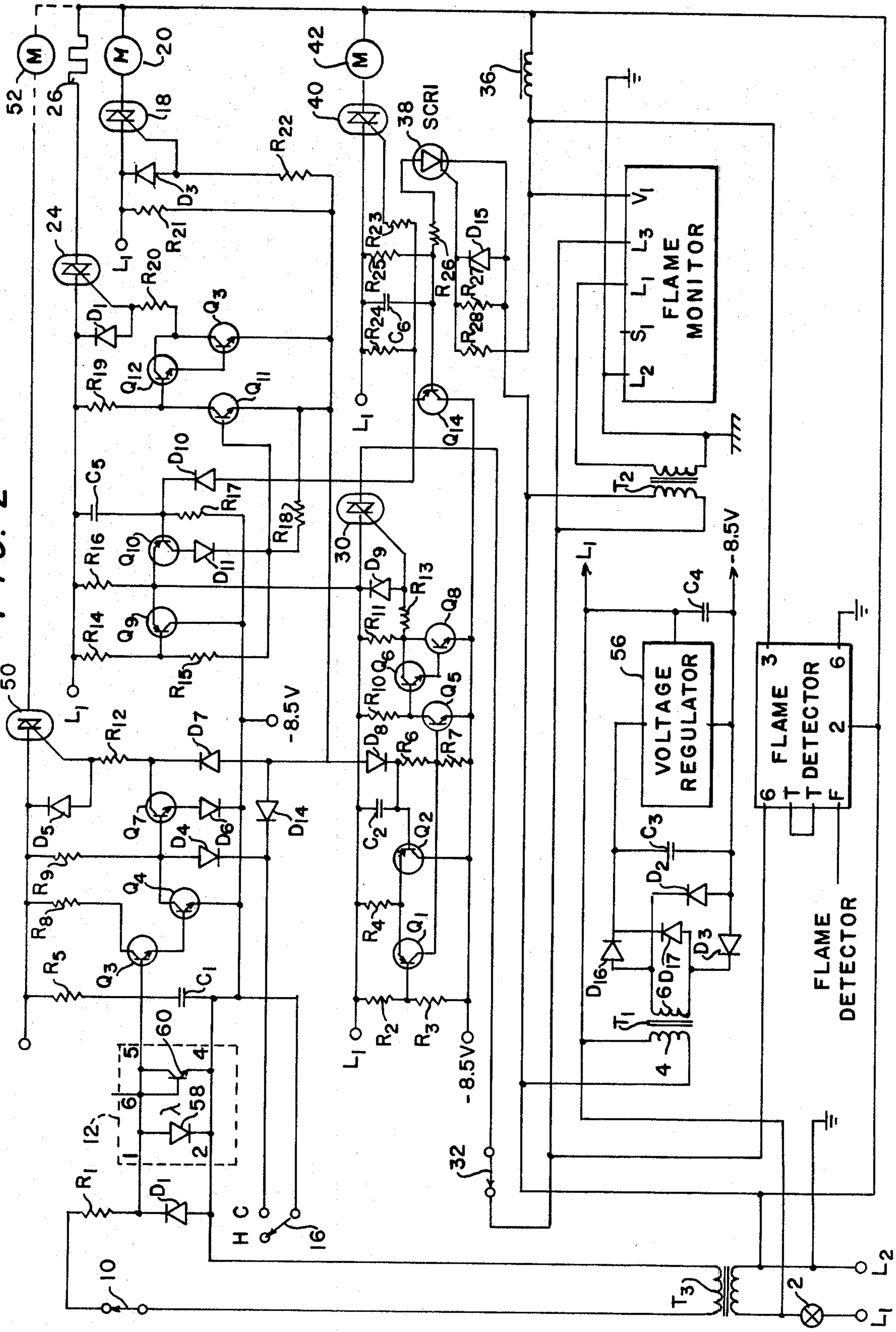

L1
24V A.C.+
11
24V-
L2
T2
10
9
12
OPTO-ISOLATOR CIRCUIT
T1
4
6
8
-8.5V
D.C. POWER SUPPLY
+
-
16
54
48
14
20
M
18
50
52
M
46
28
22
DELAY
24
26
30
32
34
FLAME MONITOR
36
44
38
DELAY
GAS VALVE OPEN DETECTOR
40
M
42

FIG. 2


52
26
M
20
18
42
40
38
SCRI
36
24
D3
R21
R22
L1
R20
D1
Q3
Q12
Q11
R19
R23
R25
R24
C6
R26
D15
R27
R28
Q14
V1
L3
L1
S1
L2
FLAME
MONITOR
C5
D10
R17
R18
R16
Q10
D11
30
D9
R13
Q8
T2
-8.5V
C4
R14
Q9
R15
R11
R10
Q6
Q5
50
R12
D7
D8
R6
R7
56
VOLTAGE
REGULATOR
C3
D5
Q7
D4
D6
D14
C2
Q2
D2
R9
R8
Q4
R5
Q3
C1
R4
Q1
D16
D17
D3
T1
6
3
FLAME
T DETECTOR
F
2
FLAME
DETECTOR
R2
R3
-8.5V
60
5
4
6
58
12
11
2
R1
D1
H C
16
32
10
T3
2
L2
L1

GAS APPLIANCE CONTROL DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to an electrical control circuit for controlling the operation of a pilotless gas system. The invention finds particular utility in use with a regulated sealed combustion heating system, but can also be used in a wide variety of gas systems and appliances which require safety controls.

It is important for reasons of safety that gas appliances be equipped with a flame detection and control circuit which will assure shut off of gas when no flame is present. The control must also allow for a period of ignition when the gas is on even though there is no flame. When the gas has not been ignited, the system must operate to quickly close the gas valve.

There are a number of types of gas appliances, including heating and air conditioning systems, stoves, dryers, etc., for which such a flame detection and proof device is required. For many years, gas appliances have operated with a pilot light system which ignites the main gas jet when the appliance is turned on. However, in recent years it has been recognized that such systems are not fuel or energy efficient. Consequently, other systems have been introduced to replace the pilot light type of system.

BRIEF DESCRIPTION OF THE PRIOR ART

Co-pending patent application Ser. No. 029,572, filed on Apr. 12, 1979 by the same applicants as the present invention, discloses a flame detection and proof control device which provides safe control of gas systems and appliances and which may be used in conjunction with the gas appliance control device disclosed herein. Various other types of control systems for gas burning apparatus are well known in the art, as evidenced by the U.S. Pat. Nos. to Cade, 3,840,322, to Matthews, 3,918,881, to Kaduki et al, 4,073,611, to Dahlgren, 4,082,493, and to Cade 4,133,419. While the prior devices normally operate quite satisfactorily and are more energy efficient than pilot light type systems, they do possess the inherent drawback of not being suitable for operating with a regulated sealed combustion system.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide an electrical control circuit for controlling the operation of a pilotless gas system including an igniter and a gas supply valve. The control circuit includes means for producing an appliance-activating control first signal which is applied to a first logic circuit to activate the igniter. A first delay circuit produces a second signal delayed from the first signal by a first predetermined delay time period, the second signal being applied to a gas supply valve control circuit for opening the gas supply valve after the first delay time period. A detector produces a third signal when the gas supply valve is in the open position, and a second delay circuit produces a fourth signal delayed from the third signal by a second predetermined delay time period. The fourth signal is applied to the first logic circuit to deactivate the igniter a predetermined delay time period after opening of the gas supply valve. The igniter is therefore activated for the first predetermined time period prior to opening of the gas supply valve, and the igniter is deactivated after the second predetermined time period following opening of the gas supply valve.

According to a more specific object of the invention, the control first signal producing circuit includes a plurality of voltage sources and a second logic circuit operable in response to power from at least one of the voltage sources.

It is a further object of the present invention to provide a control circuit wherein the second logic circuit includes an OR gate having a pair of inputs and an output. One of the voltage sources includes a thermostatically controlled optoisolator circuit connected with one input of the OR gate, and another of the voltage sources comprises a logic power voltage source and a low-limit switch connecting the logic power voltage source with the other input of the OR gate. The control first signal thus appears at the output of the OR gate.

According to a further object of the invention, the gas supply valve control circuit includes a high-limit switch and a flame monitor connected in series with the high limit switch. The opening of one of the high-limit switch and flame monitor automatically closes the gas supply valve to shut off the gas supply.

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent from a study of the following specification when viewed in the light of the accompanying drawings, in which:

FIG. **1** is a block diagram of the control circuit; and

FIG. **2** is a schematic diagram of the control circuit.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring first more particularly to the preferred embodiment of FIG. **1**, an electrical control circuit for controlling the operating of a pilotless gas system is connected with supply lines **L1**, **L2** having a given supply voltage (for example, 110 volts AC). Transformer **T1**, having a primary winding **4** connected across the supply lines, supplies low-voltage power via secondary winding **6** to the regulated DC power supply means **8** (for example, a regulated rectifier circuit, as will be described below).

Step-down transformer **T2** is provided having a primary winding **9** connected across the supply lines **L1**, **L2**, which transformer includes a low voltage (i.e., 24 volts AC) secondary winding **10** connected in series with room thermostat **11** and opto-isolator circuit **12**. The opto-isolator circuit is of conventional design and comprises an infrared light-emitting diode that illuminates a photosensitive transistor. The opto-isolator provides the required isolation between **L1** and the low voltage control circuitry that would otherwise be provided by a relay or a transformer. The opto-isolator is advantageous in that it requires virtually no power from the low voltage control transformer **T2**, it has no moving parts, an indefinite life, and it has an input-to-output breakdown rating of approximately twice that required in the industry.

In accordance with the invention, means for producing an appliance-activating control first signal is provided.

Opto-isolator circuit **12** has an output terminal connected with one of the inputs of an OR logic gate **14**. The DC power supply **8** is connected with the other input of the OR gate **14** via a low-limit switch **16**. Preferably the control first signal appears at the output of the OR gate when one of the inputs to the OR gate is activated. Thus the appliance is activated either through closing of the thermostat **10** via the opto-isolator circuit **12**, or through closing of the low-limit switch **16**.

In accordance with the invention, first logic means responsive to the control first signal for activating the igniter, and first delay circuit means responsive to the first signal for producing a second signal delayed from the first signal a first predetermined delay time period are provided. It is preferred that the first signal appearing at the output of OR gate **14** is supplied to three different circuits—namely, to a pump circuit including single-pole, single-throw switch **18** and furnace pump motor **20**; to first logic means for activating the igniter, here including AND gate **22**, switch **24**, and igniter **26** (which here comprises a conventional resistance igniter); and to a first delay circuit **28** which produces a second signal delayed from the first signal by a first predetermined time delay period (for example, 60 seconds).

The second signal appearing at the output of first delay circuit **28** activates a gas supply valve control circuit including switch **30**, high-limit switch **32**, flame monitor **34**, and gas supply valve **36**. The gas supply valve **36** opens after the first predetermined delay time period to supply gas to igniter **26**, whereby gas is normally ignited by the igniter.

In accordance with the invention, detector means **38** is provided for producing a third signal when the gas supply valve is in the open position. As here embodied the detector means is comprised of detector **38**. The detector third signal is supplied to a blower circuit including a switch **40** and the blower **42**, in response to opening of the gas supply valve **36**. In accordance with the invention, second delay circuit means is provided comprised of circuit **44**. The detector third signal also is supplied to second delay circuit **44** which produces a fourth signal delayed from the third signal by a second predetermined delay time period (i.e., 5 seconds) following opening of gas supply valve **36**. Second delay circuit **44** is connected with AND gate **22** via inverter **46**, whereby the fourth signal deactivates igniter **26** a predetermined time period after opening of the gas supply valve.

The system further includes a circulator control logic circuit including AND gate **48**, switch **50**, and circulator motor **52**. The output terminal of opto-isolator circuit **12** is connected with one input of AND gate **48** and low-limit switch **16** is connected with the other input of AND gate **46** via inverter **54**.

The control first signal is produced at the output of OR gate **14** in response to either closing of system thermostat **10**, or closing of system low-limit switch **16**. The control first signal simultaneously activates pump **20**, first delay circuit **28**, and igniter **26**. Igniter **26** warms up for a first predetermined time period prior to opening of gas supply valve **36**, and upon opening of the gas supply valve, the igniter remains activated for a second predetermined time period which allows for combustion of the gas in response to the igniter. After the second predetermined period of time, the igniter is deactivated and ,he appliance continues to operate. If for some reason combustion of the gas does not occur prior to deactivation of the igniter, then after the igniter is deactivated, flame monitor **34** senses that there is no flame in the system and opens the gas supply valve circuit, which automatically closes the gas supply valve to shut off the gas supply. Similarly, if the temperature of the system exceeds a predetermined high limit, high-limit switch **32** opens, and the gas supply valve automatically closes. Thus the control circuit affords improved energy efficiency and safety in a pilotless gas system.

The control circuit of FIG. **1** which embodies the present invention is shown in greater detail in the schematic diagram of FIG. **2**. The DC power supply for the electrical control circuit includes the transformer **T1**, diodes **D2**, **D3**, **D16**, and **D17** connected in rectifying arrangement in the secondary winding circuit of **T1**, capacitor **C3** connected across secondary coil **6** of **T1**, and integrated circuit voltage regulator **56** connected in parallel with the capacitor **C3**. The voltage regulator regulates the logic circuit power supply voltage to precisely 8.5 volts. The voltage regulator is a self-protecting device which will shut off automatically in the event of any component failure or excessive heat, to shut off the appliance. The negative terminal of the power supply is labeled −8.5 volts. This is relative only to the logic circuitry, all of which is referenced to **L1**. The −8.5 volt line is always negative relative to **L1** and is in no way directly referenced to **L2** or ground.

As here embodied, opto-isolator circuit **12** connected with thermostat **10** includes infrared light-emitting diode **58** and phototransistor **60**. When the thermostat **10** closes, the presence of resistor **R1** causes a current to flow through LED **58** during one half-cycle of the applied voltage. The LED actuates photo-transistor **60** to conduct 60 times per second, thereby keeping the capacitor **C1** discharged and transistors **Q3** and **Q4** cutoff, and thus allowing transistor **Q7** to conduct. When Q7 conducts, switch **50** is actuated to turn on the circulator **52**, and switch **18** is actuated through diode D7 to turn on pump **20**. If, however, low-limit switch **16** is closed, then transistor Q7 is prevented from conducting by diode **D4**. Similarly, with low-limit switch **16** closed, switch **18** will be powered through the diode **D14**, and the circulator **52** will be prevented from operating by diode **D4**.

Gas supply valve open detector **38** comprises a semiconductor rectifier **SCR-1**. Prior to any command for heat, the rectifier **SCR-1** detects zero voltage to the gas valve, signaling that the valve is closed. With zero voltage at the valve, transistor **Q14** is cutoff and the resistor **R24** maintains the transistor **Q10** cutoff through the diode **D10**. When transistor **Q10** is cutoff, transistor **Q11** is cutoff, allowing transistors **Q12** and **Q13** to conduct whenever diode D7 or diode **D14** conducts, thereby drawing current from switch **24** to activate igniter **26**.

The command for heat also reverse biases the diode **D8** and allows the capacitor **C2** to charge through resistors **R6** and **R7**. After the first predetermined delay time period sufficient for igniter **26** to heat, the transistor **Q2** conducts, thereby cutting off transistors **Q1** and **Q5** and allowing transistors **Q6** and **Q8** to conduct. Thus, switch **30** is turned on to supply power to the gas supply valve through high-limit switch **32** and flame monitor **34**. In a further embodiment, a flame detector **62** is also provided in the gas supply valve control circuit.

When the gas valve open detector semiconductor rectifier **SCR-1** detects the voltage at the open gas sup-

ply valve **36**, transistor **Q14** turns on the blower **42** through switch **40** and reverse biases the diode **D10**. The capacitor **C5** then charges through the resistor **R17** until the transistor **Q10** conducts, which in turn causes transistor **Q11** to conduct. As a result, transistors **Q12** and **Q13** are cutoff to deactivate the igniter **26** after the second predetermined delay time period.

Any interruption of voltage to the gas supply valve while heat is being commanded will cause an immediate repowering of the igniter, and power will not be removed from the igniter until the completion of the second delay time period after the gas supply valve is opened.

The electical control circuit uses no relays and comprises all solid state electronics. The circuit is preferably arranged on a single plug-in circuit board which is removably connected with the gas appliance system. Thus, in the event of circuit failure, the damaged control circuit may be replaced with a substitute control circuit and the damaged circuit may be taken to the shop or factory for repair.

While in accordance with the provisions of the Patent Statutes the preferred forms and embodiments of the invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made without deviating from the inventive concepts set forth above.

What is claimed is:

1. A control circuit for controlling the operation of a pilotless gas system including igniter means and a gas supply valve, comprising:

means for producing an appliance-activating control first signal;

first logic means responsive to said first signal for activating said igniter means;

first delay circuit means for producing a second signal delayed from said first signal by a first predetermined delay time period;

gas supply valve control circuit means responsive to said second delayed signal for opening the gas supply valve after the first predetermined delay time period for exposing said igniter means to said gas;

detector means for producing a third signal when the gas supply valve is in the open position; and

second delay circuit means for producing a fourth signal in response to said third signal after a second predetermined delay time period, said fourth signal being applied to said first logic means to deactivate the igniter means said second predetermined time period after opening of the gas supply valve, whereby the igniter means is activated for the first predetermined time period prior to opening of the gas supply valve, and the igniter means is deactivated after the second predetermined time period following opening of the gas supply valve.

2. A control circuit as defined in claim **1**, wherein said appliance-activating control first signal producing means includes:

a plurality of voltage sources; and

second logic means operable in response to power from at least one of said sources for producing said control first signal.

3. A control circuit as defined in claim **1**, wherein said gas supply valve control circuit means includes:

high-limit switch means; and

flame monitor means connected with said high-limit switch means for automatically closing the gas supply valve when one of said high-limit switch means and said flame monitor means opens.

4. A control circuit as defined in claim **3**, wherein the gas system includes a blower, and said control circuit includes means connected with said detector means for operating the blower in response to said third signal.

5. A control circuit for controlling the operation of a pilotless gas system including an igniter means and a gas supply valve, said control circuit comprising:

means for producing an appliance-activating control first signal, including

a plurality of voltage sources and

second logic means operable in response to power from at least one of said plurality of voltage sources for producing said control first signal, said second logic means including an OR gate having a pair of inputs and an output, and wherein one of said plurality voltage sources includes a thermostatically controlled opto-isolator circuit means connected with one input of said OR gate, and another of said plurality of voltage sources includes a logic power voltage source, and a low-limit switch connecting said logic power voltage source with the other input of said OR gate, said OR gate providing said control first signal at its output;

first logic means responsive to said control first signal for activating said igniter means;

first delay circuit means for producing a second signal delayed from said control first signal by a first predetermined delay time period;

gas supply valve control circuit means responsive to said second delayed signal for opening said gas supply valve after said first predetermined delay time period for exposing said igniter means to gas;

detector means for producing a third signal when said gas supply valve is in the open position; and

second delay circuit means for producing a fourth signal in response to said third signal after said second predetermined delay time period, said fourth signal being applied to said first logic means to deactivate said igniter means said second predetermined time period after said detector means detects the opening of said gas supply valve, whereby said igniter means is activated for said first predetermined time period prior to said gas supply valve opening and said igniter means being deactivated after said second predetermined time period following said gas supply valve opening.

6. A control circuit as defined in claim **5**, wherein the gas system also includes a pump, and said control circuit includes means connected with the output of said OR gate for operating the pump in response to said control first signal.

7. A control circuit as defined in claim **6**, wherein the gas system also includes a circulator, and said second logic means includes:

a first AND gate for producing a fifth signal, said first AND gate having a pair of inputs and an output, said thermostatically controlled opto-isolator circuit means being connected with one input of said AND gate;

inverter means for connecting said low-limit switch with the other input of said first AND gate; and

means connected with the output of said first AND gate for operating the circulator in response to said fifth signal.

8. A control circuit for controlling the operation of a pilotless gas system including an igniter means, a gas

supply valve, and a blower, said control circuit comprising:

means for producing an appliance-activating control first signal;

first logic means responsive to said control first signal for activating said igniter means, said first logic means including

an AND gate for producing a fifth signal, said AND gate having a pair of inputs and an output, one of said inputs being connected to said control first signal and

means connected with the output of said AND gate for activating said igniter means in response to said fifth signal;

first delay circuit means for producing a second signal delayed from said control first signal by a first predetermined delay time period;

gas supply valve control circuit means responsive to said second delayed signal for opening said gas supply valve after said first predetermined delay time period for exposing said igniter means to gas, said gas supply valve circuit means including

high-limit switch means and

flame monitor means connected with said high-limit switch means for automatically closing said gas supply valve when said high-limit switch means and said flame monitor means open;

detector means for producing a third signal when said gas supply valve is in the open position;

second delay circuit means for producing a fourth signal in response to said third signal after said second predetermined delay time period, said fourth signal being applied to said first logic means to deactivate said igniter means said second predetermined time period after said detector means detects said gas supply valve opening, whereby said igniter means is activated for said first predetermined time period prior to said gas supply valve opening and said igniter means is deactivated after said second predetermined time period following said gas supply valve opening;

inverter means for connecting said second delay circuit means with the other input of said AND gate in said first logic means; and

means connected with said detector means for operating said blower in response to said third signal.

* * * * *